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Adjusting Safeguards Implementation when the IAEA is Unable to Reaffirm a Previously Drawn Safeguards Conclusion

G. A. Anzelon, Y. Feldman, M. W. Goodman, K. Budlong Sylvester

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Adjusting Safeguards Implementation when the IAEA is Unable to Reaffirm a Previously Drawn Safeguards Conclusion

George Anzelon,[1] Yana Feldman,[1] Mark Goodman,[2] and Kory Budlong Sylvester[3]

[1] Lawrence Livermore National Laboratory, Livermore CA 94551 USA
[2] U.S. Department of State, Washington, DC 20520 USA
[3] Los Alamos National Laboratory, Los Alamos, NM 87545 USA

Abstract

This paper explores the question of how the State-level safeguards approach for a State with a comprehensive safeguards agreement and an additional protocol in force should be modified in the event the IAEA Secretariat finds it no longer can reaffirm the so-called broader conclusion that all nuclear material required to be safeguarded under the agreement remains in peaceful activities. It argues that the concepts for effective safeguards implementation at the State level still should apply: An updated acquisition-path analysis should be performed, taking full account of the circumstances and findings that prevented reaffirmation, in order to identify what specific, objectives-based changes in safeguards activities may be needed to restore effective coverage of all plausible acquisition paths for the state. Examples are provided to illustrate these ideas.

I. The broader conclusion and its implications for State-level safeguards

For each State with a comprehensive safeguards agreement (CSA) and an additional protocol (AP) in force, the International Atomic Energy Agency (IAEA) plans, conducts, and evaluates results from safeguards activities intended to enable it each year to draw or reaffirm a conclusion that all nuclear material required to be safeguarded under the agreement remains in peaceful activities. This conclusion is often called the "broader conclusion."[1]

The logical structure of the broader conclusion.

In order to draw the broader conclusion, the IAEA Secretariat not only must establish confidence that *declared* nuclear material has not been diverted from peaceful use, it also must ascertain that there is credible assurance (albeit necessarily qualitative) of the absence of *undeclared* nuclear materials and activities in the State as a whole that would give rise to a safeguards concern. These dual requirements—sometimes referred to as verifying both the "correctness" and the "completeness," respectively, of a State's declaration—are depicted schematically in Fig.1.

As suggested in Fig. 1, reaching each of the two major findings (correctness and completeness) necessary to support drawing the broader conclusion requires two types of sub-evaluation:

- Ascertaining that safeguards activities conducted in the field and at IAEA Headquarters were sufficient to have provided a meaningful probability of detecting, as applicable,

[1] This is term is intended to distinguish the broader conclusion from a more circumscribed conclusion (sometimes called a conclusion on non-diversion) that all *declared* nuclear material remained in peaceful use.

indications of diversion of declared nuclear material or indications of undeclared nuclear material and activities.

- Ascertaining that no such indications were observed that would give rise to a safeguards concern.

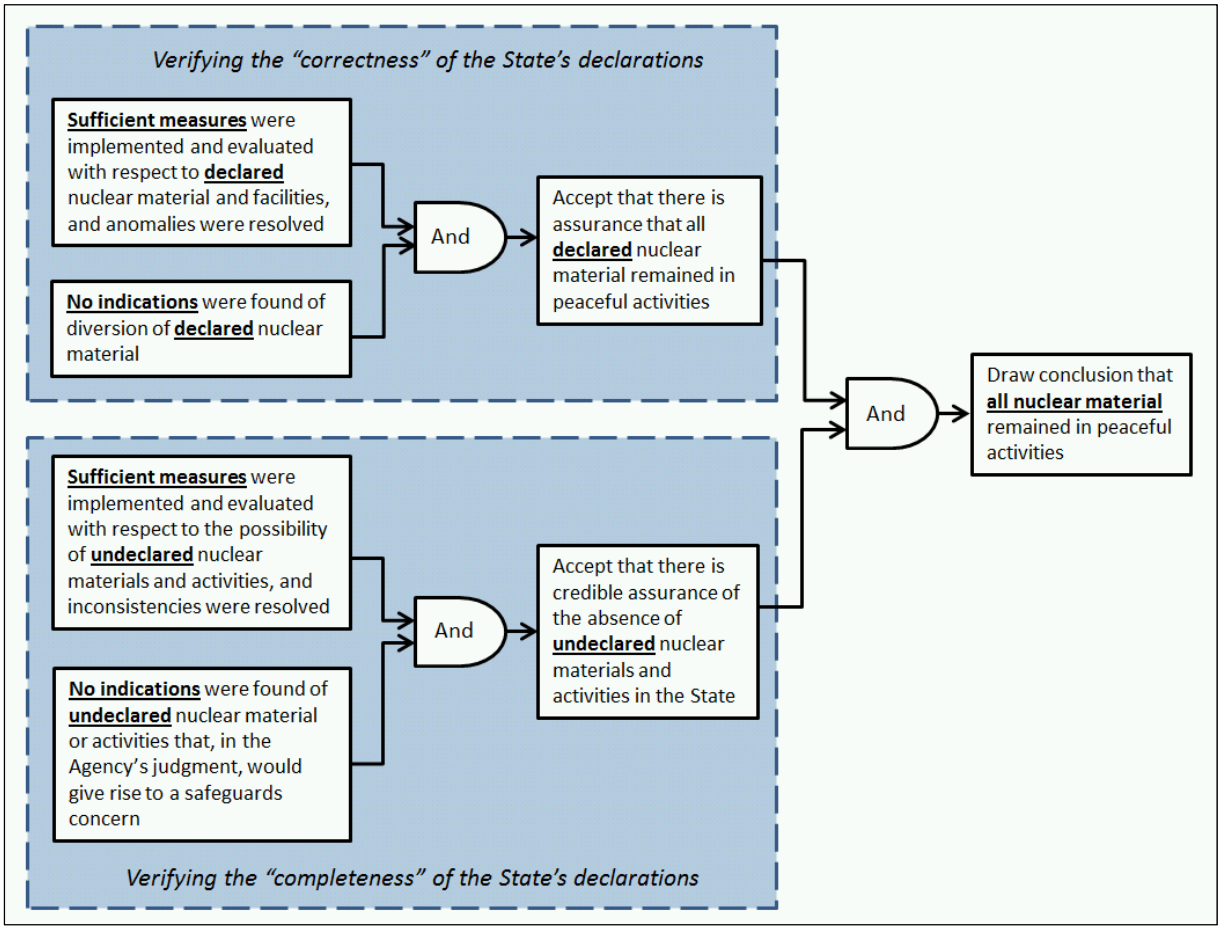

Fig. 1. A simplified depiction of the logical structure of the broader conclusion. Drawing the broader conclusion involves the testing of two hypotheses: first (as represented in the upper shaded box) that declared nuclear material has not been diverted, and second (as represented in the lower shaded box), that there are no undeclared nuclear materials or activities in the State as a whole that give rise to a safeguards concern. Each of those tests depends in turn on two types of sub-evaluation: first, whether sufficient safeguards activities were implemented and performed, and second, whether unresolved indications were found to contradict the hypothesis.

Implications for safeguards activities.

In States where the IAEA has established sufficient confidence in the absence of undeclared nuclear material and activities to support drawing the broader conclusion, that same confidence can be taken into account in designing the State-level safeguards approach (SLA). The greater the assurance that there are no undeclared nuclear facilities anywhere in the State, for example, the more confidently the IAEA can assess that any hypothetical acquisition strategies that would begin with diversion of depleted, natural, or low-enriched uranium (DNLEU), or with diversion

of irradiated fuel, would take longer to accomplish—and would afford more opportunities for detection—than if such clandestine facilities already existed or were well along in development.[2] Thus, the broader conclusion "*paves the way for reductions in verification effort on declared nuclear material that would need further processing to make it nuclear-weapon usable*."[3] Indeed, since the introduction of Integrated Safeguards in 2002, and continuing under today's further evolved State Level Concept (SLC), SLAs for States with the broader conclusion have typically incorporated significant reductions (relative to the Safeguards Criteria) in the frequency and intensity of the safeguards activities applied to DNLEU and irradiated fuel.

II. What if the IAEA finds it cannot reaffirm a previously drawn broader conclusion?

Sixteen years since the first broader conclusion was drawn, and with the IAEA having drawn the broader conclusion for 67 states as of 2015,[4] there has not yet been a single case where the broader conclusion, once drawn, was withheld in a subsequent year. Despite this record, one can envision circumstances where one or another of the conditions required for the broader conclusion (see Fig. 1) might not be met as fully as hoped, either because the Agency lacked the information or access necessary to conduct sufficient safeguards activities or because safeguards activities that were conducted revealed inconsistencies of potential safeguards concern that have not yet been resolved. Because the assurances underpinning the broader conclusion play such a significant role in the design of the SLA being implemented in that State,[5] it is appropriate to ask how the SLA would need to be modified should the IAEA find that its confidence in the absence of diversion or in the absence of undeclared nuclear material and activities has eroded.

A key point is that, in our view, non-reaffirmation of the broader conclusion need not trigger an automatic, across-the-board re-application of the measures, frequencies, and intensities specified in the Safeguards Criteria, as implemented at facilities in the State before the broader conclusion was drawn. As the Secretariat has explained,[6] under the SLC, customized SLAs will be developed for *all* States, regardless of whether the broader conclusion has been drawn or an AP is being implemented. This implies if the broader conclusion for a State is not affirmed or is called into question, it will be necessary and appropriate for the Secretariat to conduct an updated acquisition path[7] analysis—in light of the new circumstances that have called the conclusion into

[2] The Safeguards Criteria are based on the presumption that such clandestine facilities may exist.
[3] IAEA, GC(46)/8, 29 July 2002.
[4] IAEA Safeguards Statement for 2015. (The broader conclusion also was drawn for Taiwan, China.)
[5] Other State-specific factors also play a role: See Jill Cooley, "Overview of the Development and Discussion on State-Level Safeguards Implementation," presented at the 2014 IAEA Safeguards Symposium, Vienna, 20-24 October 2014.
[6] Jill Cooley, "Overview of the Development and Discussion on State-Level Safeguards Implementation," presentation to 2014 IAEA Safeguards Symposium (Vienna, 20-24 October 2014).
[7] An acquisition path is a series of (hypothetical) steps by which, from a technical standpoint, a State could obtain nuclear material for use in a nuclear explosive device. An acquisition path could include, for example, diversion of declared nuclear material followed by further processing of that material in undeclared nuclear facilities.

question—and consider what changes to the SLA might be needed in order to restore adequate safeguards coverage of all plausible acquisition paths and ensure safeguards effectiveness going forward. In some cases, that analysis may indicate that quite substantial changes to the safeguards approach are needed at many or even all facilities, but in other cases the changes may be more bounded. As discussed in the following section, much depends on the specific circumstances.

It is not this paper's purpose to suggest what safeguards conclusion the Secretariat should draw from its technical findings in any particular situation, especially with reference to any real-world case. For the purposes of the study described in this paper, we simply postulated several hypothetical scenarios in which various building blocks of the broader conclusion were not fulfilled or were in serious doubt, and for some of them we will suggest what changes to the SLA might be needed to maintain or restore adequate coverage of all plausible acquisition paths.

III. Scenarios

As suggested in Fig. 1 and noted earlier, one can distinguish between two broad types of situation that could hinder the drawing of the broader conclusion. One category (call it Type I) occurs when the IAEA has been ***unable to implement sufficient safeguards measures***, perhaps because the State is unable to facilitate the necessary access. While this type of situation impedes activities designed to confirm non-diversion or absence of undeclared activities, it does not necessarily contradict previous findings, especially where the lack of access is caused by circumstances clearly beyond that State's control and where there is little possibility the State could exploit those circumstances for proliferation purposes

The second category (call it Type II) arises when implemented safeguards measures, whether in the field or at IAEA headquarters, ***reveal specific indications of diversion of declared material, misuse of declared facilities, or undeclared nuclear material and activities*** [that could give rise to a safeguards concern]. As a general proposition, this type of situation could have wider-ranging impact than Type I, especially if it appears the State made a deliberate attempt to conceal or misreport activities, calling into question assessments that previously had underpinned the State's SLA.

A notional State

For purposes of illustration, we will imagine scenarios built around a notional State with light water power reactors (LWRs) but no enrichment or reprocessing facilities, as illustrated in Fig. 2 below. The State has had an AP in force for twelve years and first attained the broader conclusion eight years ago. More specifically, according to its declarations about its nuclear program, the State:

- Produces uranium ore concentrate and exports it for conversion and enrichment
- Imports 4% enriched UF_6
- Has LWR fuel fabrication facilities, including deconversion of low-enriched UF_6 to UO_2
- Has eight LWRs and two more under construction with high domestic content

- Imports near-20% enriched fuel elements for research reactors
- Has two LEU-fueled (near-20%) light water research reactors (10 MW and 30 MW)
- Has a post-irradiation examination (PIE) hot laboratory and other hot cells
- Formerly operated a reprocessing laboratory that was decommissioned 10 years ago; has announced its intent to pursue geological disposal rather than close the fuel cycle
- Has a large technical university conducting nuclear fuel cycle R&D without nuclear material

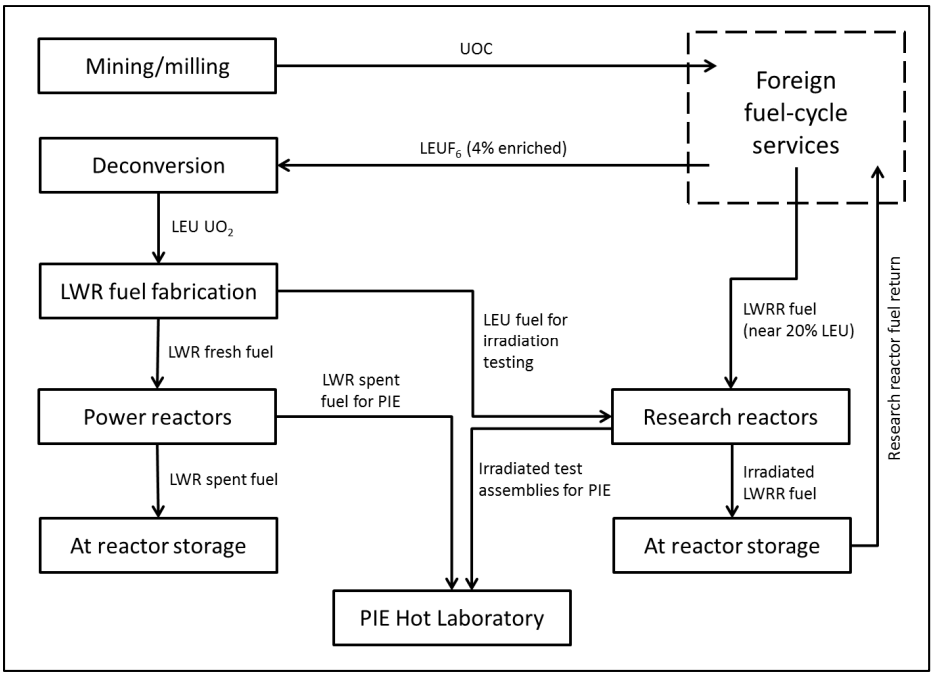

Fig. 2. The declared fuel cycle for the notional state use in this paper's example scenarios. (UOC = uranium ore concentrate; PIE = post-irradiation examination; LWR = light water power reactor; LWRR = light water research reactor; and LEU = low-enriched uranium).

Scenario list

Several potential scenarios were postulated for the notional State that spanned both Type I questions (insufficiency of safeguards measures performed) and Type II situations (discovery of indications); these are listed below. We do not intend to judge whether or not the broader conclusion would or should be reaffirmed in any specific scenario in this list; rather, we simply aim to illustrate how the scenarios affect the plausibility and safeguards coverage of various acquisition paths, and to consider what adjustments to the SLA would be needed to ensure effective safeguards.

Type I. Implementation of sufficient measures is hampered by lack of access

- A severe radiological accident renders nuclear material inaccessible for verification.
- A civil war or insurgency makes travel to certain nuclear facility sites unsafe, despite the State's readiness to accept inspectors.

- The State loses de facto control over a portion of its territory that:
  - Contains no declared locations or other locations of current interest to the IAEA, or
  - Contains uranium production facilities, a 10-MW LEU-fueled research reactor, and LWRs under construction.
- The State refuses to permit inspectors access to an undeclared location requested for Article 5(c) complementary access, or to adjacent locations.

Type II. The IAEA finds indications of diversion, misuse, or undeclared activities

- The Agency finds indications of possible diversion of LWR spent fuel.
- The Agency finds indications of possible misuse of a large research reactor.
- The Agency discovers a small quantity of undeclared nuclear material and indications of possible undeclared reprocessing R&D.
- The Agency identifies credible indications of possible undeclared activities related to gas-centrifuge enrichment.

IV. Discussion of specific scenarios and their implications

It would not be possible in this short paper to review all of the above scenarios. We will discuss three of them briefly, however, to provide a sense of how one might approach the problem.

Scenario 1: The State loses control over territory that contains an operational nuclear facility and other safeguards-relevant locations

In this scenario, the notional State has lost de facto control over a portion of its territory that has fallen under the military control of a neighboring non-nuclear-weapon State that refuses to permit access to the area by the notional State's authorities. The affected region (see Fig. 3) includes a 10-MW research reactor, uranium mines and mill, and two LWRs under construction.

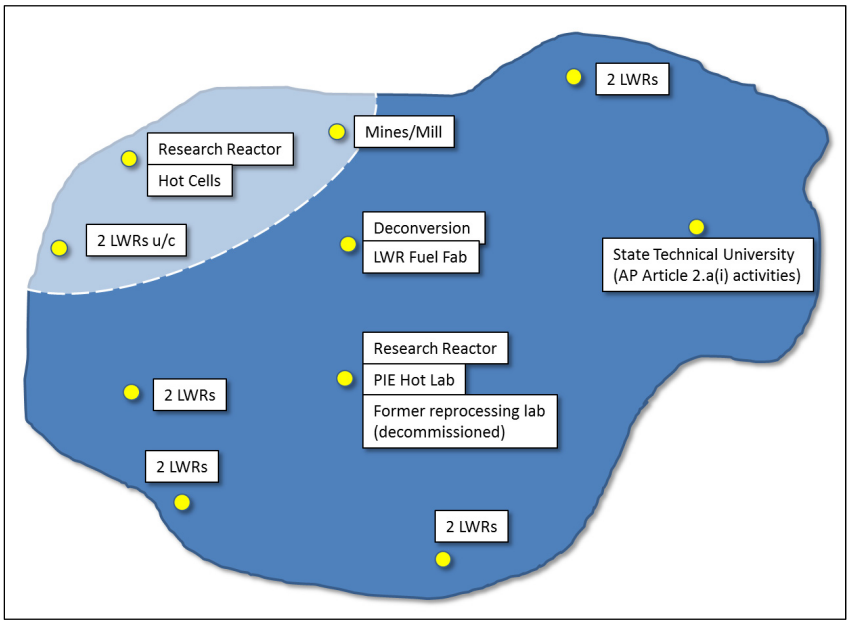

Fig. 3. Overview of Scenario 1. The State has lost de facto control of part of its territory, including a nuclear facility and other relevant locations

The State's inability to facilitate access currently prevents IAEA physical verification of fresh and irradiated LEU fuel at the 10-MW research reactor (<0.5 SQ[8] in all). It also prevents design information verification at the LWR construction site, although work there appears to have been suspended. The IAEA will be unable to conduct complementary access (CA) at the research reactor's hot cells, where swipe samples previously had been taken every few years, or at the uranium production facilities, which had been visited three times in the 15 years since AP implementation began.

This scenario involves what we have called a "Type I" issue, a question of whether the IAEA is able to conduct necessary safeguards activities. Unlike in a "Type II" scenario, no indication has been found of diversion, misuse, or undeclared activities, but without physical access the IAEA's ability to confirm that there are no such activities in the affected territory will diminish over time. But a question of interest for this paper is *whether and how safeguards implementation activities should be modified with respect to the facilities, sites, and other locations in the territory still under the State's control.* Relevant observations include the following:

- First, the State appears to lack any plausible means to use the territory outside its control to support the execution of acquisition paths involving diversion from, or misuse of, the LWRs or other declared facilities and inventories still under its control. For example, it seems implausible the State would successfully establish a clandestine enrichment or reprocessing facility in the occupied region. Thus, acquisition paths involving diversion or misuse at facilities under the State's control have not been made any easier or faster as a result of the circumstances that prevent the IAEA's access to the occupied region.
- Although the IAEA lacks access to the occupied region, the State's ability to divert material from or misuse facilities in that region is severely limited. On the other hand, this may pose a serious safeguards concern with respect to the occupying state.
- Furthermore, the assurance the IAEA already had established about the State's lack of enrichment and reprocessing activities remains relevant, and the IAEA's ability to carry out activities to ensure the absence of undeclared activities in the territory accessible to the State remains undiminished.
- ***Consequently, even if the Secretariat found it could not draw the broader conclusion for the State as a whole, no major adjustments to the frequency and intensity of safeguards activities at the State's reactors and other declared installations would appear to be called for in the near term***.
- Certain adjustments in headquarters-based safeguards activities would be appropriate, including concerted efforts to monitor locations of interest in the affected territory

[8] SQ = significant quantity. For uranium enriched to less than 20% U-235, one SQ corresponds to 75 kg of contained U-235.

through commercial satellite imagery, for example, and via information requests to the occupying state or other third parties.[9]

Scenario 2: The IAEA discovers a small quantity of undeclared nuclear material and also indications of possible undeclared reprocessing R&D

In this "Type II" scenario we postulate that the IAEA has discovered possible evidence of an undeclared effort to produce, clandestinely irradiate, and reprocess uranium targets. 50 kg of 4%-enriched UO_2 in the form of pellets and rods was discovered during complementary access at a university location not declared to have nuclear material. Furthermore, analysis of swipe samples from hot cells associated with the State's 30-MW research reactor revealed indications of recent operations with irradiated LEU that appear more consistent with plutonium extraction than with the State's declared post-irradiation examination activities.

In response to IAEA requests for clarification, the State explained that the university had recently initiated a project to perform advanced quality-control diagnostic testing on fresh fuel produced in a modified process at the State's commercial fuel fabrication facility and that, through an oversight, proper declarations and reports had not been submitted as required but would be provided immediately. Follow-up sampling at the hot cells, however, confirmed earlier findings there, and lacking satisfactory explanations from the State to date, the Secretariat finds is cannot assure the absence of undeclared activities and has told the State it will not be able to reaffirm the broader conclusion.

These circumstances have implications for several potential plutonium-route acquisition paths that will require additional attention. Potential adjustments could include the following:

- Tighten the timeliness and detection-probability goals for safeguards measures at the deconversion/fuel fabrication facility.
- Conduct more frequent 2-hour-notice CA at the PIE hot laboratory and periodically confirm the decommissioned status of the former reprocessing laboratory; also take swipe samples at the 10-MW research reactor's hot cells in conjunction with the annual PIV.
- Install a power monitor at the 30-MW research reactor (if there is not one already).
- Increase the frequency of complementary access at the uranium mines and mill.
- Increase targeted information-collection and targeted complementary access activities to detect indications of reprocessing R&D at undeclared locations.
- Increase targeted information collection and analysis on possible enrichment-related R&D, primarily to reinforce the Agency's understanding of the State's nuclear fuel cycle capabilities in order to provide continuing assurance of the absence of undeclared enrichment-related activities and ensure that the existing coverage of uranium-based acquisition remains adequate.

[9] Furthermore, the Agency may need to reconsider the safeguards conclusions drawn and measures applied to the occupying state.

- Increase detection-probability goals for spent fuel at the LWRs, including measures to increase ability to detect partial defects (pin removal). Remote monitoring of surveillance data to increase timeliness also could be considered. If questions about possible undeclared reprocessing R&D are not resolved soon, consider adjusting the timeliness goal at all LWRs from 1 year to 3 months.

Scenario 3: The IAEA identifies credible indications of possible undeclared activities related to gas-centrifuge enrichment

In this "Type II" scenario, we posit that a third party has provided the IAEA with information alleging the existence of an undeclared program to establish a uranium enrichment capability. The information suggests that a planned site not far from the uranium mill will house a plant to convert uranium ore concentrate to UF_6. The information named a firm alleged to be involved in manufacturing and testing gas centrifuges and named a site where the State allegedly plans to build a 1,000-centrifuge enrichment pilot plant.

In its effort to corroborate and evaluate the information, the IAEA has noted that the firm named in the third-party information had been identified a year earlier, in information voluntarily provided to the Safeguards Department by another State under the IAEA's procurement outreach program, as seeking to acquire flow-forming machines, balancing machines, and high-frequency power supplies. A CA visit to the firm confirmed the presence of flow-forming machines, which the firm said were for non-nuclear applications, and of general-purpose precision CNC machine tools. Satellite imagery of the vicinity of the alleged sites of planned UF_6 and pilot enrichment facilities showed nothing to indicate ongoing construction or narrow down a specific location.

Meanwhile, an environmental sample taken at a university mass spectrometry laboratory revealed a few particles containing 3% to 5% enriched uranium in the form of UO_2F_2 (consistent with enrichments expected from single-machine or few-machine testing of gas centrifuges fed with 4% enriched UF_6), along with uranium-bearing particles at enrichment levels associated with calibration standards occasionally used at the laboratory. The State denied any plans for domestic uranium enrichment and suggested the samples must have been cross-contaminated.

In this "Type II" scenario, although the IAEA still lacks information to confirm the third-party allegations, it has found credible indications of possible undeclared nuclear activity that call into question the broader conclusion. In contrast with the previous scenario, the loss of assurance with respect to undeclared activities is greatest with respect to those that would support uranium-route acquisition paths, and the adjustments needed to the SLA would likely reflect that. Potential adjustments might include, for example:

- Significantly tightening the timeliness and detection-probability goals for detecting diversion of low enriched UF_6 at the deconversion/fuel fabrication facility.
- Initiating increased, targeted activities, including headquarters-based information collection and analysis and in-field complementary access, to develop and pursue leads related to UF6 production and enrichment activities.

- Allocating increased attention to monitoring, to the extent possible using complementary access, satellite imagery, and other relevant information, the production and disposition of domestically produced uranium ore concentrate.
- Increased safeguards at research reactors and hot cells could be considered, primarily to reinforce the Agency's understanding of the State's nuclear fuel cycle capabilities in order to provide continuing assurance of the absence of undeclared reprocessing-related activities in order to ensure that the existing coverage of plutonium-based acquisition remains adequate.

V. Conclusion

For States with CSAs and an AP in force, the IAEA's ability to draw the broader conclusion that all material *required to be safeguarded*[10] remains in peaceful activities depends on a number of factors and logical building blocks. The range of circumstances that could jeopardize maintaining that conclusion is correspondingly broad. Even though there has not yet been an instance where the IAEA has not reaffirmed a previously drawn broader conclusion, it is useful to anticipate what the implications of losing the broader conclusion would be on the State-level safeguards approach across that wide spectrum of potential scenarios. Ensuring effective safeguards should be the main consideration in our view, and rather than revert mechanistically to prescribed criteria at all facilities, we recommend continuing to take advantage of a State-level perspective. If the broader conclusion is not reaffirmed or is otherwise called into question, the SLA should be re-examined taking into account the case-specific circumstances, to determine what acquisition paths are newly plausible or newly underdefended by safeguards measures, and noting which material inventories, facilities, and activities could contribute to those underdefended acquisition paths. In that way, one could determine in a thoughtful, systematic way what specific changes in safeguards technical objectives and their levels of attainment are needed to restore adequate acquisition path coverage.

As the few scenarios discussed in this paper illustrate, the adjustments required to the existing SLA may be minor—especially in cases where the problem relates to lack of IAEA access that results from conditions entirely outside the State's ability to control or to exploit for proliferation purposes—or may be quite significant in the case where specific indications of diversion or undeclared activities have been discovered. Even in those cases where quite significant changes to the SLA are indicated, a State-specific acquisition path analysis can help focus that added safeguards effort where it will do the most to restore safeguards effectiveness.

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[10] This includes both declared material that is under safeguards and possible undeclared material that should have been declared and placed under safeguards.